

ABSTRACT

An embodiment of the present invention is a method of forming an ultra-thin dielectric layer, the method comprising the steps of: providing a substrate having a semiconductor surface; forming an oxygen-containing layer on the semiconductor surface; exposing the oxygen-containing layer to a nitrogen-containing plasma to create a uniform nitrogen distribution throughout the oxygen-containing layer; and re-oxidizing and annealing the layer to stabilize the nitrogen distribution, heal plasma-induced damage, and reduce interfacial defect density.

This annealing step is selected from a group of four re-oxidizing techniques:

- 15 • Consecutive annealing in a mixture of H₂ and N₂ (preferably less than 20 % H₂), and then a mixture of O₂ and N₂ (preferably less than 20 % O₂);
- annealing by a spike-like temperature rise (preferably less than 1 s at 1000 to 1150 °C) in nitrogen-comprising atmosphere (preferably N₂/O₂ or N₂O/H₂);
- 20 • annealing by rapid thermal heating in ammonia of reduced pressure (preferably at 600 to 1000 °C for 5 to 60 s);
- annealing in an oxidizer/hydrogen mixture (preferably N₂O with 1 % H₂) for 5 to 60 s at 800 to 1050 °C.